TRANSMISSION OBJECTIVES

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1. INTRODUCTION

1.1 This section provides REA borrowers, consulting engineers and other interested parties with technical information on transmission objectives for use in the design and operation of telephone loop and interoffice trunk facilities. The emphasis in this document, with the exception of Section 4, is on voice frequency transmission parameters to be used in the **design** of analog and digital facilities. The objective levels contained herein can also be used as guidelines for operating performance, recognizing that certain, older facilities may not fully comply. Noncompliance with these design objectives for in-service facilities should not be construed to mean that a particular facility is necessarily in need of upgrade or replacement. **These objectives are advisory.**

1.2 The emphasis in Section 4, Voiceband Data Transmission, is distinctly different than that provided in Sections 2 and 3 for the loop and trunk objectives. Here, the stated objectives are performance oriented, and not design oriented.

1.3 This revision replaces both REA TE&CM 415 Issue No. 4 (May 1973) and its Addendum No. 1 (November 1978). The current reissue reflects the increasing deployment of digital facilities in local exchange plant, including use of digital loop carrier systems and remote switching terminals. This revision addresses the post-divestiture and equal access considerations and terminology of today's toll network. A separate discussion is also provided on other more specialized analog parameters that affect data transmission.

1.4 The transmission objectives presented in this TE&CM are the result of research from various sources, such as equipment specifications, ANSI standards, REA publications, reference texts, etc. Existing standards (particularly *ANSI T1.506-1989*) and other industry specifications have been utilized to the extent possible, with some modification where needed to either reflect the more rural nature of REA borrowers' facilities or to modify a performance standard into a design standard. The primary sources of information used in the preparation of this document as well as additional references for reader information have been included in the Selected Bibliography.

1.5 The principal intent of this revision is to present REA borrowers with a single collection of meaningful transmission design objectives while comprehensive national standards for a wide variety of voice frequency parameters are still evolving. As regulatory and national standards are further refined in the specific areas that are addressed in this document, REA borrowers are encouraged to adopt those standards in lieu of the information presented here. As is necessary, this TE&CM will be revised accordingly as other standards develop.

1.6 This document does not address measurement techniques. The reader is advised to consult the IEEE publication, *Standard Methods and Equipment to Measure the Transmission Performance of Analog Voice Frequency Circuits* ... ography.

...rier (LEC) of establishing and
... be underestimated. While an
...ome variations in noise, loss,
...r, toll calls with several links
...traveled distance will be more
... Connections involving data
...ng. With today's emphasis on
...ve local service alternatives
...aintaining quality transmission
... LEC consideration.

2. LOOP OBJECTIVES

2.1 Purpose

2.1.1 Loop facilities, which are largely analog in today's plant environment, contribute most of the total circuit loss in a switched connection even though they are relatively short in length compared to the other facilities involved in an interoffice call. The characteristics of a local loop affect the quality of both local and toll calls. As a result, loop facilities are in many ways the controlling link in terms of transmission quality. This section will address loop objectives under a variety of configurations, both for standard subscriber loops and PBX (private branch exchange) loops.

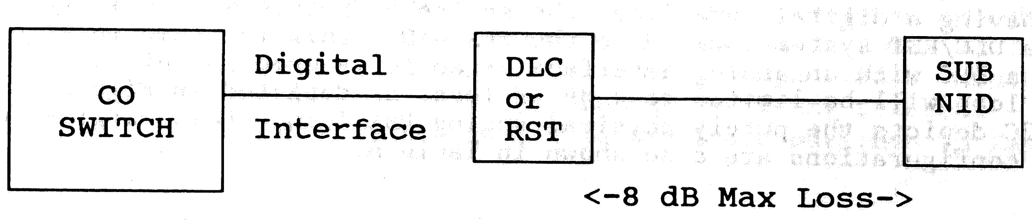
2.2 Loop Loss

2.2.1 The general foundation for loop loss is based upon a maximum of 8 dB loss to the subscriber's network interface device (NID). The specific transmission loss objectives for loop facilities are dependent upon two principal characteristics: 1) the nature of the loop itself, whether it is physical or carrier-derived; and, 2) the nature of the loop interface to the central office switch, whether it is analog or digital. Carrier-derived loop circuits result whenever subscribers are served by either a digital loop carrier (DLC) or an analog carrier (AC) system. DLCs can either have an analog interface on a per subscriber or individual loop basis to the central office (CO) switch; or, a digital interface on a DS1 basis with the CO switch.

2.2.2 Wherever remote switching terminals (RSTs) are deployed in the loop, the interface to the CO switch is on a digital basis. Any loss directly associated with the RST unit is considered as part of the CO switch and not part of the loop. Central office insertion loss and other transmission objectives for digital CO switches are addressed in REA Form 522, *General Specification for Digital, Stored Program Controlled Central Office Equipment.*

2.2.3 As previously mentioned, the primary basis for all loop loss objectives, regardless of the type of facility or interface, is to maintain the lowest loss possible with a maximum subscriber loop loss from the NID to the CO switch of 8 dB. Where a loop is served by either a DLC or a RST with a direct digital interface to the switch, the full 8 dB of loss is available from the DLC/RST location outward to the subscriber. This situation is depicted in Figure 1A. Should a specific DLC or RST in an integrated mode insert any additional loss into the loop circuit, the 8 dB margin should be reduced accordingly.

**FIGURE 1A - MAXIMUM LOSS
CARRIER-DERIVED LOOP
DIGITAL INTERFACE**



2.2.4 Wherever a DLC or a AC is deployed and the interface to the CO switch is on an analog basis (sometimes known as a universal interface for the DLC), only 6 dB of loop loss is available from the location of the DLC/AC outward to the subscriber. The remaining 2 dB is assigned to the DLC/AC. This configuration is depicted in Figure 1B.

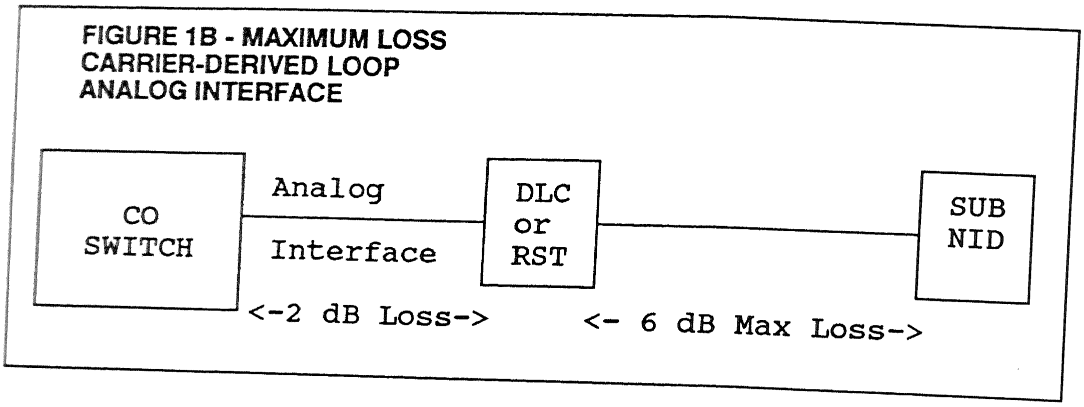


FIGURE 1B - MAXIMUM LOSS
CARRIER-DERIVED LOOP
ANALOG INTERFACE

2.2.5 The purely physical analog loop is depicted in Figure 1C. The maximum loss to the CO switch in this situation is 8 dB. Table A summarizes the subscriber loop loss objectives for all of the configurations discussed above.

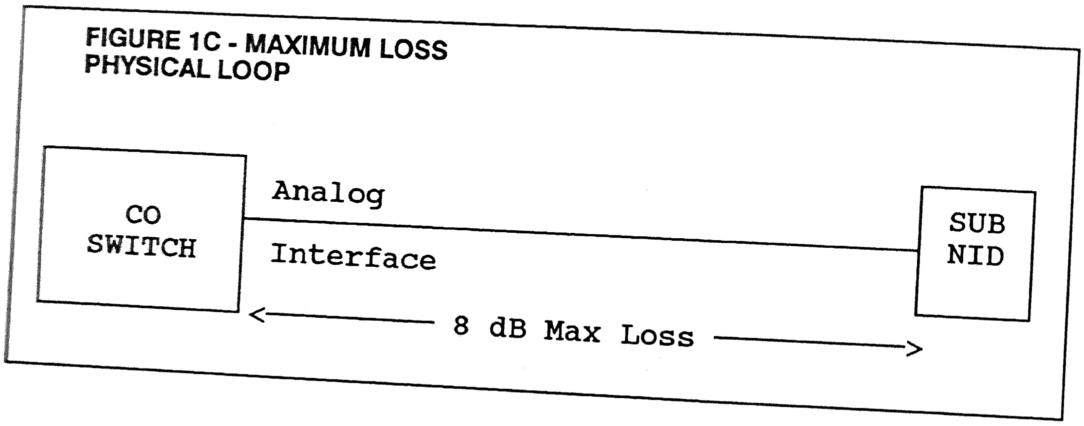


FIGURE 1C - MAXIMUM LOSS
PHYSICAL LOOP

differently for loss purposes
This is because a PBX loop
of a simple subscriber loop
ıal level of switching and
the PBX switch in terms of
:ore, are limited to 5 dB maximum
.oop served by the PBX.

:he distance from the PBX to the
:ither DLCs or RSTs. With a DLC
re 5 dB loss margin is available
NID. This is shown in Figure
n AC is used in this situation,
s, as depicted in Figure 2B.
; PBX loop. Loss margins for
ɔle A.

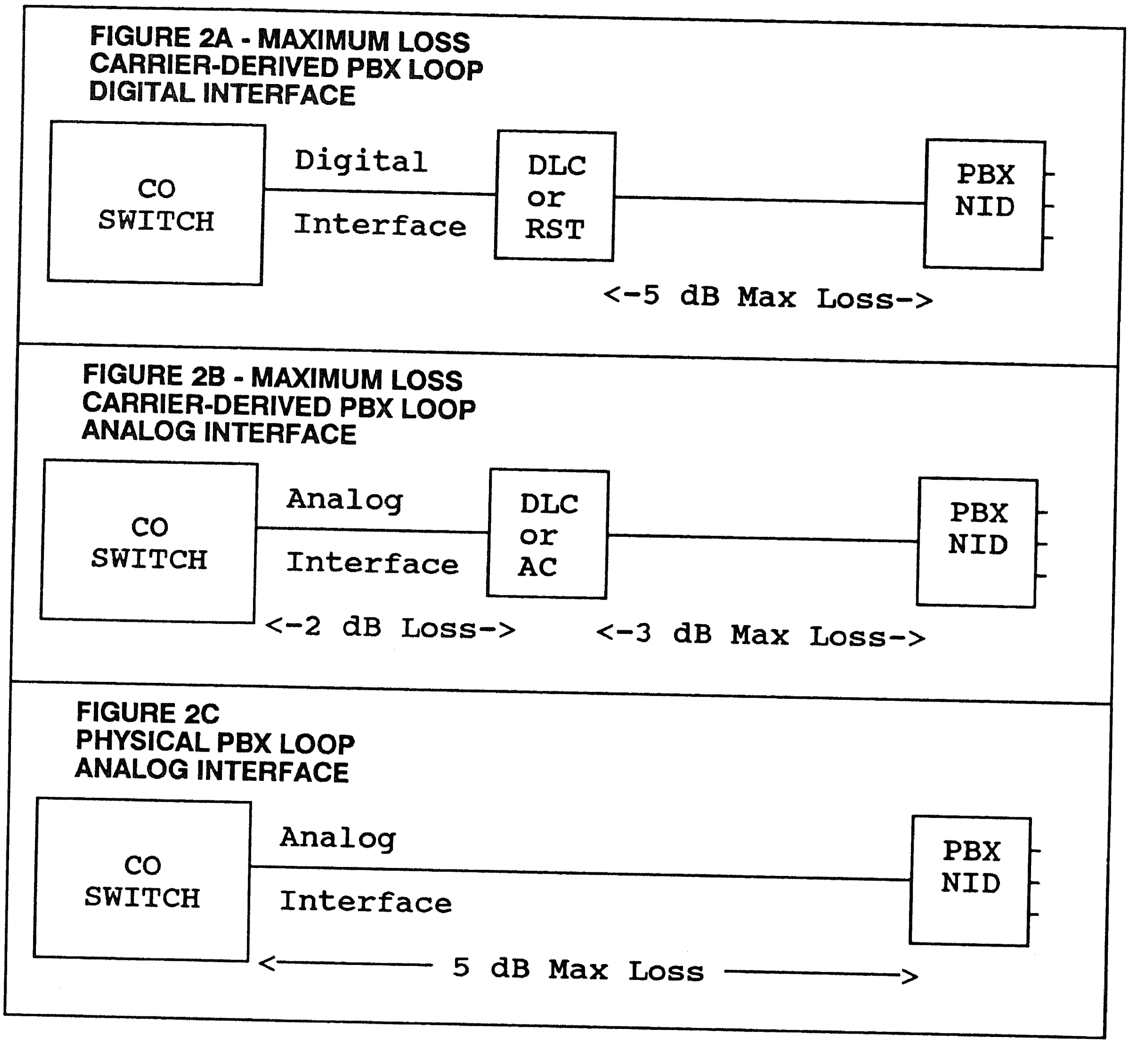


FIGURE 2A - MAXIMUM LOSS CARRIER-DERIVED PBX LOOP DIGITAL INTERFACE

FIGURE 2B - MAXIMUM LOSS CARRIER-DERIVED PBX LOOP ANALOG INTERFACE

FIGURE 2C PHYSICAL PBX LOOP ANALOG INTERFACE

2.3 Loop Current

2.3.1 To insure proper operation of customer premises (each subscriber, sufficient loop current must be loop current objective under adverse conditions (low bat generator) is ≥ 20 mA.

2.4 Loop Noise

2.4.1 The weighted noise objective fc 20 dBrnC. It is measured at the premises. The loop objectives for ste independent of the interface to the CO facility. Loop noise objectives are a

2.5 Loop Frequency Response

2.5.1 Frequency response parameters f in terms of a full spectrum req performance oriented parameter such as information on TTS may be located in R Bibliography. Loop frequency response

TABLE A
LOOP TRANSMISSION OBJECTIVES

Type of Facility	Parameters		
	Loss[2] 1004 Hz	Steady State[3] Noise	Frequency[4,5] Response
Subscriber Lines - Physical	8 dB	20 dBrnC	300-3000 Hz: +1 dB,-3 dB
Subscriber Lines - Carrier Derived w/Digital Interface at CO[1] w/Analog Interface at CO[1]	 8 dB 6 dB	 20 dBrnC 20 dbrnC	 300-3000 Hz: +1 dB,-3 dB 300-3000 Hz: +1 dB,-3 dB
PBX Trunks - Physical	5 dB	20 dBrnC	300-3000 Hz: +1 dB,-3 dB
PBX Trunks - Carrier Derived w/Digital Interface at CO[1] w/Analog Interface at CO[1]	 5 dB 3 dB	 20 dBrnC 20 dbrnC	 300-3000 Hz: +1 dB,-3 dB 300-3000 Hz: +1 dB,-3 dB

NOTES

1 Loss given is that for the physical loop facilities **beyond** the carrier system to the subscriber's network interface device (NID). Carrier systems with a digital interface to the CO switch are assumed to meet the 0 dB interface loss requirements of REA Form 522, "General Specifications for Digital, Stored Program Controlled Central Office Equipment."

2 Maximum value from either the switch or a DLC/AC unit to the subscriber's NID; and, is exclusive of any CO switch-related loss.

3 Steady state noise threshold is a maximum value measured at the subscriber's NID.

4 Loops that contain either nonloaded facilities or loaded loops with long end sections may exceed the stated objectives but should be within +1 dB, -5 dB: 300-3000 Hz.

5 Response objective is specified in terms of a gain and loss range, referenced to a 1004 Hz signal.

2.6 Loop Treatment Options

2.6.1 The application of loop treatment at the central office may be necessary to meet loop transmission objectives. Treatment takes the form of loop extenders which elevate the DC loop voltage, and VF repeaters which provide additional amplification. Treatment should be considered if: 1) the stated loop objectives cannot be met, 2) the loop ... ceeded (for information on loop ... *Guidelines for* ... or 3) if a minimum loop current

... it if subscriber densities are ... n long loops should be ... include economics, adequate ... inimization of loss and noise. ... gn consult REA TE&CM 424.

3. TRUNK OBJECTIVES

3.1 Purpose

3.1.1 This section will discuss terminology and transmission design objectives to be applied to both analog and digital intraLATA trunk facilities. For REA borrowers and other rural LECs, trunk facilities are largely of a toll nature. However, exceptions exist to this characterization where facilities are provided for extended area service (EAS), special services, operator services or local interoffice links between wire centers or other nearby exchanges.

3.1.2 Because of the significant effects on the telecommunications industry resulting from the divestiture of AT&T, the toll network has undergone many changes in recent years. Traditionally it was a strict hierarchical network operated by a single interexchange carrier (IXC). Today in the realm of interLATA competition and equal access, many carriers operate toll networks which depend upon access to LECs to terminate and route subscriber traffic. Formerly, the interoffice transmission facilities were of the analog variety; today they are largely digital. Even the terminology has changed. This section will address toll transmission objectives from a LATA access perspective while not completely ignoring the predivestiture form of toll network that is still in general use for many REA borrowers.

3.1.3 The trunk transmission design objectives are set forth in five tables: B, C, D, E and F. Those trunks classified as inter-tandem and tandem connecting have more rigorous objective levels. This reflects the desire to maintain a higher quality of transmission both for calls carried over highly segmented routes as well as for strictly toll facilities, such as intertandem. Many of the performance criteria are based upon the nature of the facility, type of access, etc. Therefore, it is recommended that the reader review sections 3.2, 3.3 and 3.4 prior to interpreting the trunk transmission objectives.

3.2 Types of Trunks

3.2.1 Because the technical characteristics and capabilities vary between analog and digital facilities, the actual objectives bear a relationship to the facility and its interface to the switch. This section will briefly define the terms analog trunk, combination trunk and digital trunk.

Analog Trunk - An interoffice facility that is either analog or digital (or a combination of the two) and that terminates both ends in analog interfaces.

Combination Trunk - A digital interoffice facility that terminates one end in a digital interface and at the other end in an analog interface.

Digital Trunk - A digital interoffice facility that terminates both ends in digital interfaces at digital switching systems.

3.3 LATA Access

3.3.1 For some categories of network segments, toll transmission objectives vary depending upon the type of switched LEC LATA access that is made available to the IXC at its point of presence (POP). The four principal types of local exchange access are described below.

Types of Local Exchange Access

Feature Group A (FGA) - A line side connection path from the end office to a specific IXC's POP.

Feature Group B (FGB) - A trunk side connection path (either direct or via a tandem switch) from the end office to a specific IXC's POP.

Feature Group C (FGC) - A trunk side connection path from the end office to AT&T-Communications. Because of its predivestiture origination, used only where Feature Group D access is not available.

Feature Group D (FGD) - A trunk side connection path from the end office to an IXC's POP. Trunking may be either direct or indirect via an access tandem switch. Known as Equal Access.

3.4 Network Configurations

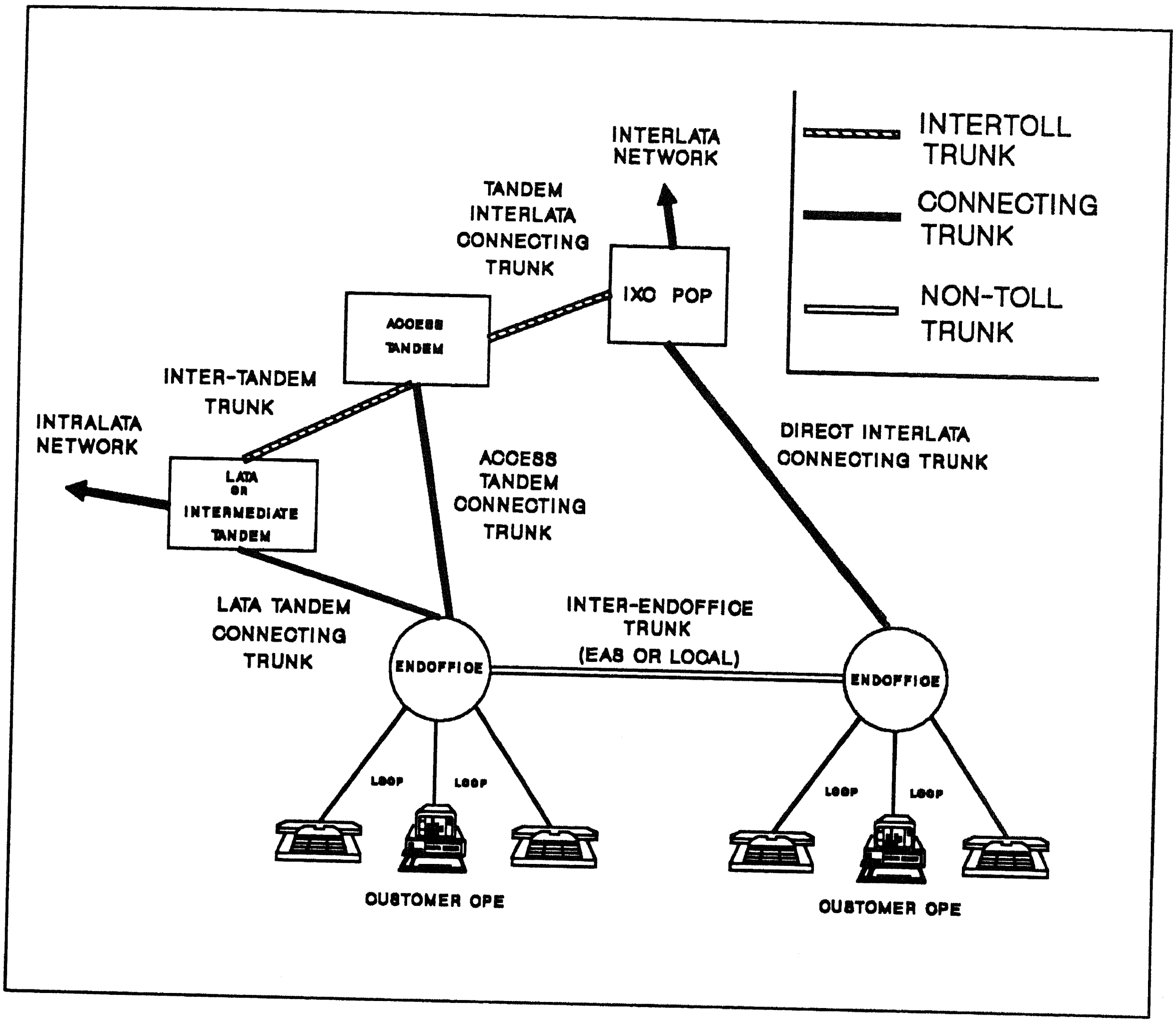
3.4.1 For purposes of discussion, toll network configurations can be placed into two broad categories - predivestiture and equal access. The former is in most cases a Bell System hierarchical network that was modified as a result of the court-ordered divestiture of AT&T to hand off all interLATA traffic at an AT&T point of presence (POP) within the LATA. IntraLATA traffic is carried by either a Bell Operating Company (BOC) or a Independent Telephone Company (ITC). In some cases, groups of ITCs have organized mutually-owned and operated, facility-based intraLATA networks.

3.4.2 Ultimately, equal access facilities should be universally available to permit Feature Group D connections from all LEC end offices to multiple IXCs. The completion of this process will require some time yet. It is dependent upon a variety of exchange-specific considerations, including end office capabilities, traffic densities, location of IXC facilities and overall economics.

3.4.3 Where equal access (Feature Group D) is not available, Feature Group A lines and/or Feature Group B trunks may exist to provide interim access and distribution of interLATA traffic to IXCs other than AT&T. These forms of access are service alternatives and are not equivalent in operation nor performance to Feature Groups C and D

3 . .

FIGURE 3
TOLL TRUNKING NETWORK



.5 **TRUNK LOSS**

.5.1 Because of the natural tendency for signals to be reflected in a network wherever impedance discontinuities occur (primarily at 2-ire/4-wire interfaces), loss is intentionally introduced to attenuate hese reflected signals. The correct amount of loss attenuates the eflected signal or echo without adversely affecting the magnitude of the rimary signal, thereby ensuring adequate voice quality. Control of eflections is particularly important on longer distance toll calls where gnal delay and echo are more apparent.

.5.2 When all interoffice trunking was analog, a national loss plan was developed by the Bell System in the 1950's to maintain minimum erall loss yet minimize the effects of echo on call performance. This an became known as Via Net Loss, or VNL. VNL is based upon the physical ngth and type of the facility. Although VNL was used successfully for ny years, it sees diminishing use today with the increased deployment of gital trunking facilities. A fixed loss plan, which is largely dependent of length, was then developed for digital facilities. ditional information on VNL is available from References # 4 and 5 in the lected Bibliography, *Notes on the BOC Intra-LATA Networks*.

3.5.3 The fixed loss plan developed for digital networks is specified in terms of two parameters. The first is simply an end-to-end loss from the analog line interface (assuming digital switches) at the originating office to the analog line interface at the terminating office. This is nominally 6 dB for digital toll facilities involving digital offices. The 6 dB is a compromise value that provides low loss on shorter toll connections, yet sufficient loss for longer connections to adequately reduce echo. Digital inter-end office trunks (local or EAS) less than 320 km (200 miles) in length are specified at 3 dB end-to-end loss. Where an analog tandem switch is employed, the fixed loss for toll connecting trunks is reduced to 5 dB. Table B depicts these end-to-end losses.

TABLE B
TRUNK END-TO-END LOSS

Type	Loss[1] End-to End
Inter-End Office (≤320 km)	3 dB
Toll via Digital Tandem	6 dB
Toll via Analog Tandem	5 dB

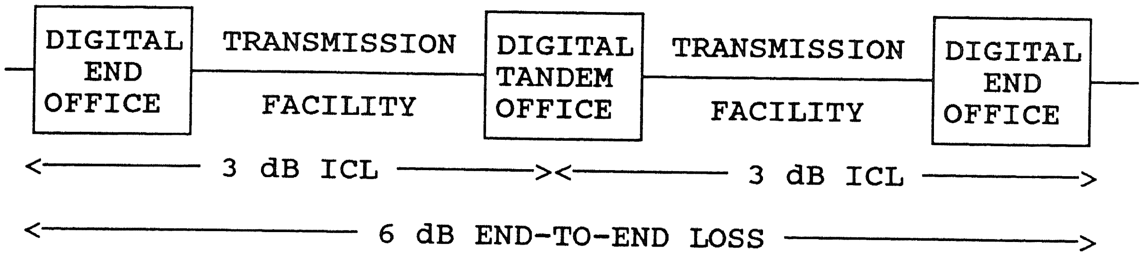
NOTES

1 Measured from the analog line interface at the originating office to the analog line interface at the terminating office.

3.5.5 The other parameter of the fixed loss plan for digital facilities is Inserted Connection Loss, or ICL. It is part of the end-to-end loss of a connection. Specifically, the ICL is the loss assigned per toll segment, or between switching points, of the overall connection. For digital switches the ICL appears at the decoder stage. Therefore, the ICL of a digital connection cannot be quantified or explicitly measured until the digital signal is decoded. Measurement of the entire end-to-end loss will be affected by the ICLs contained in each segment of the overall connection.

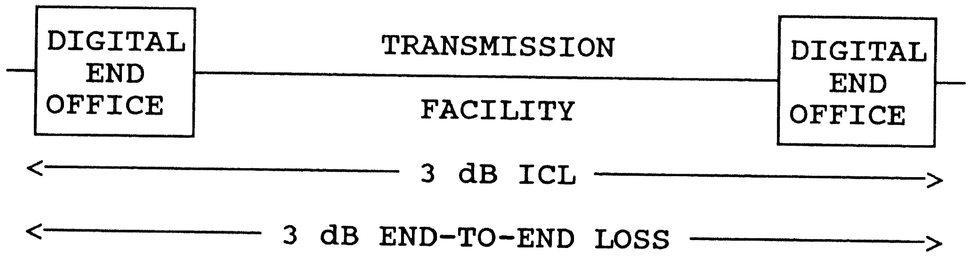
3.5.6 Figure 4A illustrates the ICL in a digital CO to digital CO connection involving one digital tandem switch. Here the end-to-end loss is 6 dB; the ICLs for the two tandem connecting digital toll trunks are 3 dB each. It must be emphasized, however, that the overall end-to-end loss is not determined by the numerical addition of all the ICLs. In certain circumstances, such as depicted in Figure 4A, the end-to-end loss can equal the sum of the ICLs; in others it does not. Additional Loss beyond the ICL may be inserted to attain the required end-to-end loss. This may occur in the form of loss pads or as the result of certain loss or gain inherent in particular equipment, such as channel banks.

FIGURE 4A
ICL & END-TO-END LOSS
DIGITAL END OFFICE-DIGITAL TANDEM-DIGITAL END OFFICE



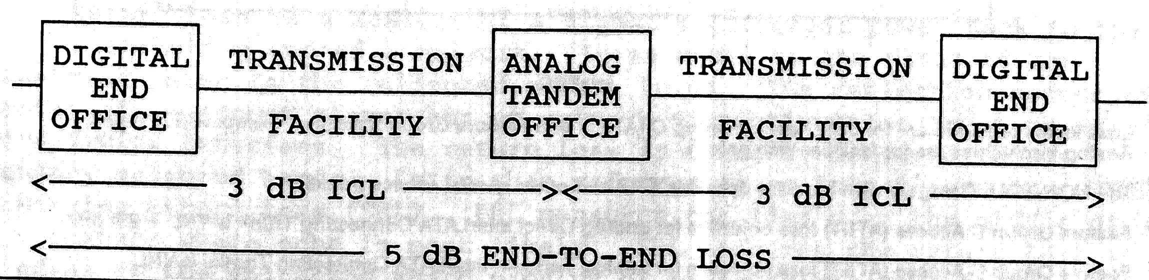
3.5.7 Figure 4B depicts a local end office to end office trunk where the total end-to-end loss is 3 dB. The ICL for this trunk configuration (distances ≤ 320 km) happens also to be 3 dB. The 3 dB ICL occurs at the decode point at the terminating end of the connection.

FIGURE 4B
ICL & END-TO-END LOSS
LOCAL DIGITAL END OFFICE - DIGITAL END OFFICE



3.5.8 For analog switches, the ICL is the difference between the outgoing signal of the originating switch and the outgoing signal of the terminating switch. Loss is normally introduced into this configuration with analog loss pads at the receive-end channel bank. Figure 4C shows the ICL for a digital end office-analog tandem-digital end office connection. Here, the ICL for each individual toll connecting trunk is 3 dB. But, because of the analog tandem switch, the end-to-end loss is 5 dB.

FIGURE 4C
ICL & END-TO-END LOSS
DIGITAL END OFFICE-ANALOG TANDEM-DIGITAL END OFFICE



3.5.9 In general, the ICL for most connecting trunks is 3 dB, regardl of whether analog, digital or combination facilities are involv Long inter-end office facilities are specified at 6 dB, inter-tandem generally at 0 dB and tandem connecting at 3 dB. Table C depicts the I values for these trunks and others. It also provides ICL values for th various forms of inter-LATA access trunks. References # 4 and 5 in the Selected Bibliography provide additional information on ICL.

TABLE C
TRUNK TRANSMISSION
INSERTED CONNECTION LOSS (ICL)

Type of Facility	Loss[1]
I. NON-TOLL[2]	
Inter-End Office (≤ 320 km)	3 dB
II. TANDEM CONNECTING	
Access Tandem Connecting Digital Combination Analog (≤ 320 km)	 3 dB 3 dB 3 dB
Direct InterLATA Connecting Digital Combination Analog[3]	 3 dB 3 dB 3 dB
LATA Tandem Connecting Digital Combination Analog (≤ 320 km)	 3 dB 3 dB 3 dB
III. INTER-TANDEM	
Inter-Tandem Digital Combination Analog	 0 dB 1 dB VNL
Tandem InterLATA Connecting Digital Combination Analog[4]	 0 dB 0 dB 0 dB

NOTES

1 Loss levels provided are for both Feature Group C (AT&T) and Feature Group D Access, except where noted. Analog loss values are for facilities with gain.

2 The NON-TOLL Category also includes operator, EAS and other special service trunks.

3 Feature Group C Access (AT&T) loss objective for analog Direct InterLATA Connecting Trunk is VNL + 2.5 dB.

4 Feature Group C Access (AT&T) loss objective for analog Tandem InterLATA Connecting Trunks is VNL.

3.6 TRUNK NOISE

3.6.1 The noise objectives for trunk circuits are specified as a short-term, average noise level performed on an idle channel at the analog interface. The measurement is C-message weighted to more accurately reflect the relative responses of both the human ear and a standard telephone set. The measured noise level is also referenced to a standard noise power of -90 dBm, or 10^{-12} watts. Objective noise levels in units of dBrnC0 for trunking facilities are outlined in Table D.

TABLE D
STEADY STATE OBJECTIVE NOISE LEVELS FOR TRUNKS

Type of Facility	Noise Objective[1,2]
I. NON-TOLL	
Digital	26 dBrnC0
Combination/Analog	
0 -100 km	30 dBrnC0
100-200 km	32 dBrnC0
II. TANDEM CONNECTING	
Digital	24 dBrnC0
Combination/Analog	
0 -100 km	28 dBrnC0
100-200 km	30 dBrnC0
III. INTER-TANDEM	
Digital	24 dBrnC0
Combination/Analog	
0 -100 km	28 dBrnC0
100-200 km	30 dBrnC0

1 Objective level is defined as a recommended minimum for facility design.

2 Where digital switches employ digital loss pads, the stated objective may be increased by 1 dBrnC0.

3.7 TRUNK RETURN LOSS

3.7.1 Return Loss is a measure of a signal's reflected power back to the originating end of a network. It is equal to the ratio of the transmitted power to the reflected power, in dB. The reflection occurs as a result of impedance mismatches at network discontinuities, such as at a 4-wire/2-wire interface. The return loss is commonly measured in two frequency-weighted bands. It is then referred to as Echo Return Loss (ERL) and Singing Return Loss (SRL). ERL measures the loss over the middle of the voiceband where echo is most likely. SRL measures the return loss at the edges of the voiceband where singing or oscillations tend to occur.

3.7.2 It is important to ensure adequate return loss at tandem switch locations where 4-wire/2-wire interfaces are sometimes located to maintain proper balance. If all end offices, tandem switches and trunks are 4-wire, then trunk return loss need not be a concern. Where necessa return loss measurements are performed on tandem connecting trunks to an from end offices connected via 2-wire trunks. This is known as terminal balance. Terminal balance objectives for trunking facilities are shown i Table E.

TABLE E
TERMINAL BALANCE TRUNK OBJECTIVES[1]

Type of Facility	Return Loss ERL	Return Loss SRL
TOLL CONNECTING TRUNKS		
Digital	23 dB	17 dB
Combination/Analog	18 dB	12 dB

NOTES

[1] Objective level is defined as a recommended minimum for facility design.

3.8 TRUNK FREQUENCY RESPONSE

3.8.1 Frequency response parameters for toll trunks have been defined in terms of a full spectrum requirement and not in terms of a more performance-oriented parameter such as Three Tone Slope (TTS). Additional information on TTS may be located in Reference # 1 of the Selected Bibliography. Frequency response objectives for trunk facilities are outlined in Table F.

TABLE F
TRUNK FREQUENCY RESPONSE OBJECTIVES[1]

Type of Facility	Frequency[2] Response
Digital	300-3400 Hz: +1 dB, -3 dB 600-2400 Hz: ±1 dB
Combination/Analog	300-3400 Hz: +1 dB, -4 dB 600-2400 Hz: ±1 dB

NOTES

[1] Objective level is a recommended minimum for facility design.

[2] Response objective is specified in terms of a gain and loss range, referenced to a 1004 Hz signal.

4. VOICEBAND DATA TRANSMISSION OBJECTIVES

4.1 Purpose

4.1.1 In addition to the more standard noise and loss parameters, additional analog characteristics can be measured and controlled on voiceband transmission facilities in order to ensure adequate data transmission. Proper control of these parameters can play a major role in the performance of data modems to accurately transmit and receive data through the public network on both physical and carrier facilities. Although these characteristics are to some extent determined in the design of transmission equipment, equipment malfunctions and harmful external influences may be detected through proper observation and measurement. Often, a single cause may be common to the simultaneous occurrence of one or more parameters exceeding the defined objectives. This section will briefly describe each of the voiceband parameters. The performance objectives are noted in Table G. For information on actual measurement techniques, the reader is referred to Reference # 8 in the Selected Bibliography.

4.1.2 The objective level for each parameter outlined in Table G was developed from the Service Affecting Limits (SALs) and other supporting information contained in *ANSI Standard T1.506-1989*. The SALs are designed for use in achieving adequate voiceband data transmission with modems operating up to 9600 bits/second. The limits are to be applied in measuring the performance of primarily trunk facilities, but some of the parameters may also be useful for evaluating loop performance. Since these are recommended minimum values, no distinction has been made between digital, analog and combination facilities. Digital facilities, however, would be expected to exhibit somewhat better performance in general than the other two facility types.

4.2 Amplitude Jitter

4.2.1 Amplitude Jitter is any fluctuation in the peak amplitude value of a fixed tone signal at 1004 Hz from its nominal value. Amplitude Jitter can be measured in two separate frequency bands, 4-300 Hz and 20-300 Hz. The wider 4-300 Hz band is important where modems that employ echo cancelling capability are used. Table G provides Amplitude Jitter objectives for both the 4-300 Hz band and the 20-300 Hz band. Amplitude Jitter is measured in terms of percent peak amplitude variation of signal amplitude.

4.3 Signal to C-Notched Noise

4.3.1 Signal to C-Notched Noise (S/CNN), or Signal to Distortion (S/D) Ratio, is the logarithmic ratio expressed in dB of a 1004 Hz holding tone signal compared to the C-message weighted noise level. Because the noise measurement is performed with a holding tone, the receive band is notched or attenuated around the 1004 Hz contour (C-message weighted) to remove this tone, leaving only the resulting noise or distortion. The holding tone can be input at either -13 dBm (the level that more closely approximates an actual data modem) or -16 dBm (the level used in many automated test systems).

4.3.2 S/CNN can be one of the most important transmission parameters affecting the performance of data transmission. Other parameters such as harmonic distortion, quantizing noise and jitter can also contribute to excessive CNN. The use of digital loss pads for level

settings is also a source of CNN. The S/CNN objectives in Table G are provided at typical modem signal levels of -13 dBm0.

4.4 Envelope Delay Distortion

4.4.1 Envelope Delay Distortion (EDD) is a measure of the linearity or uniformity of the phase versus frequency characteristic of a transmission facility. (It is also known as relative envelope delay, or RED.) If EDD is sufficiently high, various frequency components will travel at a different rate of speed with different arrival times, causing successively transmitted data pulses to overlap at the receive end. The resulting phenomenon is known as intersymbol interference and may cause significant data errors.

4.4.2 EDD is specifically defined as the delay relative to the envelope delay at a reference frequency, commonly 1704 Hz. It is typically measured at two frequencies, one low and one high in the voiceband. The objective levels for EDD in units of microseconds delay are given in Table G for 604 Hz and 2804 Hz. Remedial solutions to excessive EDD can be provided through use of improved modems with equalization or by line conditioning performed by the LEC or IXC. EDD can also be measured and quantified through Peak to Average Ratio (P/AR) techniques.

4.5 Impulse Noise

4.5.1 Impulse Noise is a measure of the presence of unusually large noise excursions of short duration that are beyond the normal background noise levels on a facility. It is typically measured by counting the number of occurrences beyond a particular noise reference threshold in a given time interval. The noise reference level is C-message weighted. Transient signals originating from various switching operations are a common source of impulse noise.

4.6 Intermodulation Distortion

4.6.1 The Signal to Intermodulation Distortion ratio (S/IMD) is a measure of the distortion produced by extraneous frequency cross products, known as intermodulation products, when a multi-tone signal is applied to a system. The test process is the 4-tone method.

4.6.2 IMD is caused by t…

…ities acting upon the harmonic
multiple tones. The products
oise in terms of producing

two nominal frequency bands: 1) 20-300 Hz and 2) either 2-300 Hz or 4-300 Hz, the latter being more appropriate for transmission with modems employing echo-cancelling techniques. Table G sets forth phase jitter objectives in terms of °p-p for the 4-300 Hz band the 20-300 Hz band.

4.7.2 PJ plays a major role in the error performance of data transmission wherever phase modulation techniques are used. The influence of power lines and other facilities through electromagnetic induction is a common cause of PJ. Digital facilities with PJ can be remedied through control of C-notched noise, impulse noise and DS1 timing.

TABLE G
VOICEBAND DATA TRANSMISSION OBJECTIVES[1]

Parameter	Value
Amplitude Jitter[2]	(maximum)
20-300 Hz	5 %
4 -300 Hz	6 %
Signal to CNN[2]	(minimum)
	31 db
Envelope Delay[3] Distortion	(maximum)
604 Hz	1500 μs
2804 Hz	1000 μs
Impulse Noise[2,4]	(maximum)
Signal to IM Distortion	
R2	
R3	
Phase Jitter	
20-300 Hz	
4 -300 Hz	

NOTES

1 Minimum performance objectives for in-service
Equivalent to the Immediate Action Limit (IAL) a
Standard T1.506-1989."

2 Measured with a 1004 Hz tone at -13 dBm0.

3 Envelope Delay Distortion objectives are showr
delay which are relative to the delay at 1704 Hz

4 Impulse Noise objectives are based upon a ma
a 5 minute period at equal or greater than the i
thresholds.

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